

## Heat Related Illness in Exercising Children and Adolescents

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## Goals and objectives

- To know the epidemiology of heat related injuries in youth sports
- To understand the physiology of heat homeostasis and the special needs of children and adolescents
- To be able to treat heat related injuries
- To be able to prevent heat related injuries

## Epidemiology of Heat Illness

- Heat waves in usually cool locations
  - From 1979-2003, 8015 deaths from heat exposure are reported in the US
- Children left in hot cars
- Exercise

## Details emerge in heat-stroke death of Kentucky high school football player

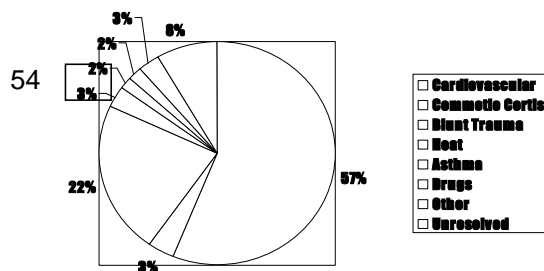
- Weather at 3:45PM with heat index of 97 degrees.
- Given three water breaks in a 30-minute period
- "Gassers" (12) started at 5:30 PM
- 6-foot-2, 220-pound offensive lineman
- Collapsed on the turf just 15 minutes after a teammate went down.
- His body temperature was 107 degrees when he reached the hospital
- Three days later, the 15-year-old was dead from heat stroke.
- Five months later, his first-year head coach is facing a reckless homicide charge.



The death was one of six heat-related deaths in high school and college athletics in 2008.

Associated Press, January 23, 2009

## Sudden Death in the US, 1980-2006, 1866 young competitive athletes (18+5, 89% male)



Maron BJ. Sudden deaths in young competitive athletes: analysis of 1866 deaths in the United States, 1980-2006. Circulation. 2009

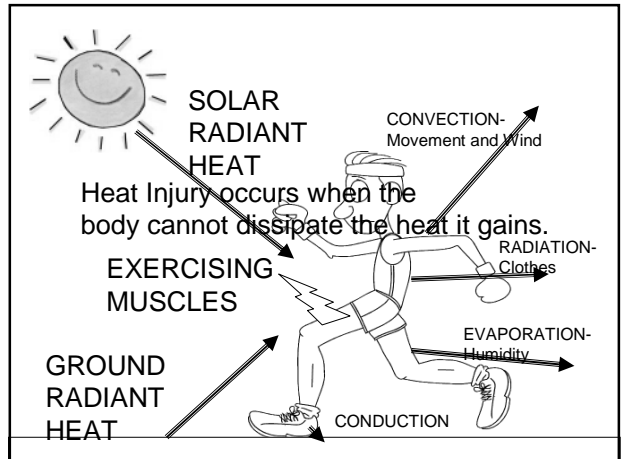
## Heat Injury occurs when the body cannot dissipate the heat it gains.

- The body gets rid of heat by:
  - Evaporation Endothermic reaction of sweat
  - Radiation Electromagnetic waves
  - Convection To surrounding gas or liquid medium (air, water, body fluid)
  - Conduction Direct contact to cooler object
- The body obtains heat by:
  - Radiant heat from the sun
  - Metabolic heat from exercise

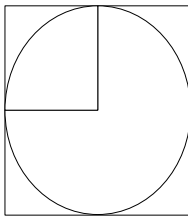
**What does the body do when it is stressed by heat?**

- Increases the amount of hot blood to the skin
- Initiates sweating

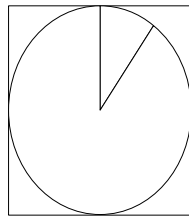
Exercise at high intensity would be **lethal** in 15 minutes if thermoregulatory measures were not in place.



•DURING REST OR EXERCISE AT LOW HEAT STRESS



•DURING EXERCISE AT HIGHER HEAT STRESS



Radiation and Convection  
 Evaporation

**Risk Factors for Heat Injury**

- Weather/Environment
- Wet Bulb Globe Temperature
  - 10% Dry Bulb (Ambient temp)
  - 20 Black Globe (Radiant)
  - 70% Wet bulb (Humidity)
- Heat Index
  - Based on light breeze and partial cloud cover



Relative Humidity (%)		With Prolonged Exposure under Physical Activity	
Heat Index	Relative Humidity (%)	Heat Index	Relative Humidity (%)
80	10	80	10
80	20	80	20
80	30	80	30
80	40	80	40
80	50	80	50
80	60	80	60
80	70	80	70
80	80	80	80
80	90	80	90
80	100	80	100
85	10	85	10
85	20	85	20
85	30	85	30
85	40	85	40
85	50	85	50
85	60	85	60
85	70	85	70
85	80	85	80
85	90	85	90
85	100	85	100
90	10	90	10
90	20	90	20
90	30	90	30
90	40	90	40
90	50	90	50
90	60	90	60
90	70	90	70
90	80	90	80
90	90	90	90
90	100	90	100
95	10	95	10
95	20	95	20
95	30	95	30
95	40	95	40
95	50	95	50
95	60	95	60
95	70	95	70
95	80	95	80
95	90	95	90
95	100	95	100
100	10	100	10
100	20	100	20
100	30	100	30
100	40	100	40
100	50	100	50
100	60	100	60
100	70	100	70
100	80	100	80
100	90	100	90
100	100	100	100

**Risk Factors for Heat Injury**

- Medical Conditions
  - Fever
  - Skin disease (Sun Burn)
  - Endocrine disease (hyperthyroid)
  - Malignant Hyperthermia (ryanodine receptor mutation)
  - Sickle Cell Trait
  - Previous EHS
  - Sleep deprivation

**Risk Factors for Heat Injury**

- Heat generation
  - Exercise intensity
  - Poor fitness
- Less efficient dissipation mechanism
  - Sweat
    - Dehydration
    - Lack of Acclimatization
    - Fitness
  - Radiant losses
    - Body Composition
    - Clothing
- Medications

## Exercise

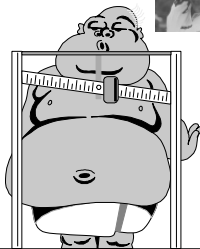
- Of all the ATP burned for exercise
  - 15-20% produce muscular contraction
  - **80-85% is liberated as heat**
- Heat produced is directly related to exercise intensity.

## Acclimatization

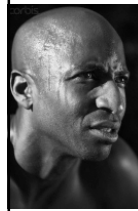
- ~~The body gets used to the heat and works better~~  
The body gets used to the heat and works better
  - metabolic and cardiovascular strain resulting from repeated exposure to heat stress.
- Increased sweat efficiency (higher rate, earlier initiation, lower [Na])
- Lower heart rate
  
- Usually takes 10-14 days
- 60-90 minutes per day, more effective when coupled with light exercise

## Radiation and Convection

- Clothes can help or hinder
- Cooling fans can help
- Insulation



## Sweat



- Cool the skin when the liquid sweat evaporates into the gas
- Sweat that drips only dehydrates
  - Higher humidity makes evaporation difficult
    - 70% RH will decrease sweat efficiency to 50%
    - 90-95% humidity makes evaporation ineffective
- Women perspire 30% less than men
  - Rates vary [mean 0.5L/hr (.1-4.5L/hr)]
- >1 % dehydration will impair sweating and performance

## Medications

- Decrease sweat
  - Anticholinergics
  - Antihistamines
- Dehydration
  - Diuretics
  - Ethanol
- Central dysregulation of sweat initiation and heat perception
  - Antidepressants
  - Lithium
  - Neuroleptics , Phenothiazines
- Fatigue perception and heat generation
  - Sympathomimetics (eg, cocaine, amphetamines)
  - Salicylates

## What is so special about kids?

- Increased surface area to body weight ratio
- Slower to acclimate
- Sweat less efficiently
  - Lower rate
  - Later initiation
- Cardiac output is lower for a given exercise intensity
- Possibly less exercise efficiency

## What is a heat injury?

- A spectrum of injuries that are related to exposure to warm ambient conditions or the body's intrinsic production of heat.



## Mild Heat Injury

- Heat edema, cramps, syncope
- Usually self limited (<1 hour)
- Get better with minimal intervention
  - Stop exercise
  - Drink cool fluid
  - Get in a cool shaded environment
  - Ice
  - Position in trendelenburg



## Moderate Heat Injury- Heat exhaustion

- Must monitor closely because this may progress to heat stroke
- Symptoms include:
  - Heavy sweating
  - Feel lousy (pale, tired, weak, dizzy)
  - Nausea or vomiting
  - Muscle cramps
  - Headache
- Low BP, High HR, elevated temp
- NO ALTERED MENTAL STATUS



## Severe Heat Injury- Heat stroke

- MEDICAL EMERGENCY
  - 20% mortality
- May present with any of the heat exhaustion S/S and VS changes
- ALTERED MENTAL STATUS IS PRESENT



## Differential Diagnosis

- Head Injury
- Street Drugs
- Cardiac Issue
- Seizure Disorder
- Hyponatremia
- Sickle crisis
- Febrile Illness
- Diabetic Ketoacidosis

NOT SO FAST



## Evaluation

- ABCs
- Mental status exam
- Stabilize C spine if AMS
- Get medical history and witness reports if available or copy of Preparticipation Sports Evaluation

- Rectal Temperature
- Vital signs
- Hydration assessment
- Weights if available



- Signs of head/neck trauma
- Pupils
- Cardiac exam

## Treatment

- Cool ASAP to about 39C
  - Cool, shaded, environmentally control area
  - External Cooling Maneuvers
    - Ice Immersion
    - Ice bags in groin, axilla, head
    - Cold towels
    - Water mist and fans
- Get IV access
- Get O2 ASAP



## What don't you do?

- NSAIDs or antipyretics
- Cool them to the point of shivering
- Measure an oral temperature
- Think that they are sweating therefore they do not have heat stroke
- Dump water over your head
- Orally rehydrate if AMS
- Push IV fluids if possible hyponatremia

## Once at definitive care area, what now?

- Monitor ABCs and vital signs
- Lab evaluation:
  - Electrolyte abnormalities
    - Sodium
    - Potassium
  - Acidosis
    - ABG
  - Hypoglycemia often with liver shock and failure
    - Glucose and LFTs
  - Muscle breakdown
    - CPK
  - Renal injury
    - BUN/Cr
    - Urine for myoglobin
    - 25-30% of EHS
  - DIC
    - CBC with d/p
    - PT/PTT, fibrinogen, D-dimer

## Treatment

- Benzodiazepines for agitation, shivering, sympathomimetic
- Inotrops like dobutamine for hypotension if cooling does not correct
- CXR for ARDS
- CT of head for AMS
- ICU management of fluids, blood pressure, respiratory failure, renal failure

**Indicators of poor prognosis during acute episodes include the following:**

- Initial temperature measurement higher than 41°C or a temperature higher than 108°F or a temperature persisting above 102°F despite aggressive cooling measures
- Coma duration longer than 2 hours
- Severe pulmonary edema
- Delayed or prolonged hypotension
- Lactic acidosis in patients with classic heatstroke
- ARF and hyperkalemia
- Aminotransferase levels greater than 1000 IU/L during the first 24 hours

**Prevention**

- Activity modifications based on
  - Dry bulb temperature, humidity, and cloud cover or WBGT
  - Fitness/Time of the season
  - Acclimatization status
  - Playing surface
- Shorten games or practice
- Reschedule
- Cooler part of the day (morning)
- Decrease intensity of practice
- Proper Rest intervals during practice

WET BULB GLOBE TEMP		ACTIVITY MODIFICATION
°F	°C	
< 75	<24	None
75-78.8	24-25.9	Longer rest in shade Water break q15 min
78-84.8	26-28.9	Restrict unacclimated Limit others
>85	>29	Cancel activity

AAP COSMF, Climatic Heat stress and the Exercising Child and Adolescent, Pediatrics, 2000.

WET BULB GLOBE TEMP		EHS RISK	ACTIVITY MODIFICATION	
°F	°C		High RF	Low RF
< 65	<18.3	SAFE	NONE	NONE
65.1-72	18.4-22.2	SAFE	Increase rest: work, √fluids	NONE
72.1-78	22.3-25.6	MILD Watch RF	+ decrease total duration	√ fluids
78.1-82	25.7-27.8	MODERATE High for RF	+ decrease intensity	√ fluids
82.1-86	27.9-30	CANCEL	R:W= 1:1 No high intensity	Caution for high intensity or long duration
86.1-90	30.1-32.2		Cancel practice/game	Limit intensity and duration
>90.1	>32.3		Cancel exercise	Cancel

Casa, D. in Athletic Training and Sports Medicine, 2005.

**Prevention**

- Proper fluid availability
  - Restriction of fluid should not be a punishment
  - Should try to drink equal to sweat rate
    - Need to know your sweat rate
    - May need to make up after
  - AAP recommends q 20 minutes
    - <40kg- 5 oz
    - >40kg- 9 oz
  - Electrolyte drink for exercise > 1hour
  - More likely to drink if cold and sweet

AAP COSMF, Climatic Heat stress and the Exercising Child and Adolescent, Pediatrics, 2000.

- There is only so much fluid that the body needs. Continuing to exercise and stress the system CANNOT be compensated for by over drinking.



## Prevention

- Acclimatization program before the season
  - Needs 10-14 days
  - 60-90 minutes/day
  - Exercise around 50% of max

## Prevention

- Monitoring for early identification
  - Daily weights
    - 1-2% watch close
    - 2-4% avoid heat
    - 4-6% avoid heat and degree exercise intensity
    - >6% no exercise, medical evaluation
  - Urine specific gravity or color
- Progressive practice
  - Inside to start
  - Progress to outside with no pads
  - Progress to practice with pads
  - Progress to scrimmage with pads
  - INTENSITY OF EXERCISE RAISES CORE TEMPERATURE

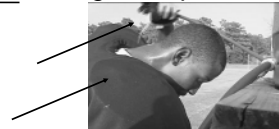
## Prevention

- Adequate Fitness and Body Composition
  - Minimizing body fat
  - Increased aerobic fitness
- Buddy system
- Clothes/ Equipment modification



## Football Practice in 98 Degree Heat

Too much heat can lead to a dangerous situation for a football player. One of the keys is awareness and the players & coaches understood how hot it was Wednesday at North Brunswick. The heat index was 105. The temperature reached 98. The Scorpions go through an average of 65 gallons of water during each practice, on a hot day.



## Football Practice in 98 Degree Heat

Head Coach chooses to practice in the late afternoon - early evening time period instead of the morning, like some teams do. " The key is to keep fluids in them. We think practicing in the evening is not a problem. We've never had a problem in 15 years and we want to keep it that way."



## Take Home Message

- Heat Injury is completely preventable.
- Heat stroke is a medical emergency.
- Exercise intensity/duration and weather are modifiable.
- WBGT is the most accurate for heat stress
- Minimize risk factors and monitor for early signs.
- Proper hydration is important but not a cure.
- Cool them down fast if identified.

## **Resources**

- **American College of Sports Medicine**
  - Exertional Heat Illness during Training and Competition
  - Exercise and Fluid Replacement
- **American Academy of Pediatrics**
  - Climatic Heat stress and the Exercising Child and Adolescent
- **Exertional Heat Illnesses, Lawrence Armstrong.**

**Thank you**

**Questions?**